Strategy – Provide Roadway Design & Geometric Enhancements

General Description

This strategy includes improvements to the roadway cross-section, which will reduce the likelihood of lane departure crashes, primarily by helping to keep the vehicle on the roadway. Past research has shown that run-off-road crashes are more prevalent on roads with lane widths of less than 11 or 12 feet, and also on roads with narrow shoulders (Zegeer, et. al. 1987 and Harwood, et. al, 2000). Studies have also shown that shoulder edge drop-offs can contribute to run-off-road and head-on crashes. According to Neuman, et. al. making improvements such as shoulder paving, widening and edge drop corrections …."enable the vehicle's recovery to be made in a more controlled fashion and at a less sharp angle, thereby reducing the chances that the recovering vehicle will over-correct into the opposing lane" (Volume 6, NCHRP 500, 2003).

In North Carolina, lane departure crashes are well over represented in terms of fatalities. Lane departure crashes account for 23% of all crashes, but comprise 55% of all fatalities. Rural roads comprise 90% of all state maintained highways and account for 84% of all lane departure crashes.

Certain geometric features at horizontal curves are also associated with increased lane departure crashes. Such features include sharp horizontal alignment, lack of proper superelevation and narrow roadway width on the curve. (Zegeer, et. al., 1991). A variety of improvement strategies for horizontal curves are available to address these deficiencies (Volume 7, NCHRP, 500, 2004).

Specific geometric enhancements which are included under this strategy on roadway geometric enhancements include:

- Eliminate sight distance obstructions where feasible
- Implement statewide program to widen the lanes and/or shoulders on narrow width roadways (20' or less) through the NCDOT resurfacing program
- Modify horizontal alignment
- Improve or restore superelevation
- Eliminate shoulder drop-offs through routine maintenance
- Implement a statewide program to construct beveled/sloped edges on all resurfacing projects

These geometric improvements can be made on roadway sections or on horizontal curves as part of routine roadway maintenance, incorporated into 3R projects, as a part of a safety improvement program utilizing federal and state safety funds, or as a part of major roadway reconstruction. (Note that much of the information contained in this strategy description was based on NCHRP Report 500, 2003, "Volume 6: A Guide for Addressing Run-off-road Collisions" and "Volume 7: A Guide for Reducing Collisions on Horizontal Curves").

A great opportunity to address these issues over the long term can be found through revising the resurfacing program to include this type of work. The North Carolina Moving Ahead Initiative exemplified the potential for one program to impact the transportation system by improving

safety and modernizing rural roads within the State. The NCMA initiative developed by NCDOT and approved by the General Assembly in 2003 is a 2year program focusing on 2 lane roadways with more than 2000 ADT. Approximately 2200 miles will be improved by widening, resurfacing, constructing turn lanes and installing enhanced pavement markings. Corridor crash data was used as screening tool for project selection. Post construction analysis should show a reduction in lane departure crashes along many of these routes. A continuation of this program should be considered.

Technical Attributes	
Target	These countermeasures apply particularly to roadway sections and/or horizontal curves on rural roads, where there is a cluster of head-on and/or run-off-the-road crashes.
Expected Effectiveness	The effects of curve flattening on crashes depends on the original curve characteristics and the new degree of curve, and is given on page V-23 of the NCHRP 500, Volume 6, (as taken from Zegeer, et. al., 1991). For example, for individual curves on two-lane roads, reconstructing a 30-degree curve to a 15 –degree curve can be expected to reduce total curve crashes by 46-to-50 percent. Correcting superelevation deficiency (i.e., insufficient amount of "banking" on the curve) can reduce total curve crashes by up to 12 percent, depending on the amount of superelevation which is needed, (Zegeer et. al. study 1991) as also given on page V-35 of Volume 6, NCHRP Report 500 (2003). The known crash effects of various amounts of road widening and shoulder drop-off improvements are less clear but have well-documented safety benefits. The corresponding crash reductions from various studies are summarized on page V-32 in Volume 6 of NCHRP Report 500. Where continuous widening is not practical, spot widening should be considered. For example, the insides of curves might be widened where topography or right-of-way is a constraint to widening the entire section of roadway.
Keys to Success	The key to success for higher-cost measures (such as roadway widening and flattening the radius of substandard horizontal curves) is to identify and target the higher-hazard locations for possible treatments. This means identifying the sites and sections that have the highest numbers and severities of lane departure crashes, as well as sites having higher levels of traffic volume and vehicle speed. For measures like correcting superelevation and edge drop problems, a key to success is to first properly locate where such problems exist and then incorporate appropriate improvements into funding programs such as routine road maintenance, 3R projects, etc. Incorporating geometric safety changes into routine maintenance and/or overlay projects may require policy changes within the NCDOT. Also, NCDOT field personnel will need training on the proposed use and implementation of the revised NCDOT 3R Guide. Retrieving the crash data and ADT on secondary roads can be tracked though GIS mapping and some of this information has already been generated for the NC Moving Ahead Program. There must be a method or system to coordinate roadway geometric, maintenance, and crash data so that corridors can be identified for improvements. A unified GIS reference system must be in place for NCDOT, law enforcement, and other agencies will be able to call up a location and determine the existing geometric conditions and past crash history. That unified system currently does not exist.

Potential Difficulties	There are certainly practical and cost limitations which come into play, particularly because of the large number of miles of roadway where such geometric enhancements are desired and with limited resources for making such safety improvements. This can be dealt with to some extent by carefully selecting the roadway spots and sections with the highest crash experience (crash numbers, rates, and severity), and also making use of a variety of roadway enhancement programs. For example, routine road maintenance activities and also 3R programs can be used to routinely eliminate shoulder drop-offs on roadway sections. Correcting the most severe horizontal curves may be programmed by reconstruction projects. Where possible, 3R projects should include safety improvement enhancements where needed, such as curve widening, shoulder paving or widening, and correction of superelevation deficiencies. Crash rates and ADT can help with prioritizing projects. However, gathering information to create a database to identify spots and locations where substandard roadway geometry exist on secondary roads will likely require a lot of work. Presently, a database that tracks this type of information does not exist. Obviously, improvement needs go well beyond the short term funding capability of the NCDOT. A process to prioritize roadway sections and corridors based on crash data combined with a system that optimizes the funding available through careful decision-making will be a mandatory part of any safety improvement program.
Appropriate Measures and Data	Data are needed on the locations and sections where deficiencies exist with respect to having high crash experience, combined with such geometric deficiencies as shoulder drop-offs, narrow lanes and shoulders, and sharp curvature and/or inadequate amount of superelevation on the curve. The impact measure would be the number of "lane departure" crashes (i.e., primarily head-on and run-off-road crashes) and also the total number of crashes reduced on the roadway sections as a result of the geometric treatments. All data must be accurately coordinated through a GIS reference system.
Associated Needs	None identified.
Organizational, Institutional, and Policy Issues	Implementing safety enhancements routinely to correct shoulder drop-offs and superelevation deficiencies may involve modifying normal practices to insure that such deficiencies are identified and corrected as a part of routine maintenance activity and 3R projects. Implementing more expensive improvements such as flattening horizontal curves and roadway widening can be conducted as a part of the state's TIP program to compete with other types of projects within available funding levels.
Issues Affecting Implementation Time	The projects involving road widening and flattening horizontal curves require time for design and reconstruction and may require the time to purchase additional right-of-way.
Costs	Lane and shoulder widening costs will depend largely on whether new right-of-way is required and the extent to which roadside modification is required. Thus, costs will vary widely between roadway sections in mountainous areas compared to flatter areas of the state. In many cases, minor widening of lanes and shoulders and/or shoulder surfacing can be accomplished more cost-effectively as part of a 3R project. The New York State DOT estimates that it spends an average of approximately $20,000 per lane mile (1995 costs) for resurfacing projects of 0.5 mile (NCHRP Report 500, Volume 6, 2003).
Training	3R Guide for NCDOT field personnel, otherwise, no special personnel needs are typically needed for implementing these strategies

Legislative Needs	None at this time.

References

C. Zegeer, R. Stewart, D. Reinfurt, F. Council, T. Neuman, E. Hamilton, T. Miller, and W. Hunter, "Cost-Effectiveness of Improvements for Safety Upgrading of Horizontal Curves", Report No. FHWA-RD-90-021, Federal Highway Administration, October 1991.

D. Harwood, F. Council, E. Hauer, W. Hughes, and A. Vogt, "Prediction of the Expected Safety Performance of Rural Two-Lane Highways," Report No. FHWA-RD-99-207, Federal Highway Administration, December, 2000.

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